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TITLE: Risk direct asset allocation and risk resolved CAPM for optimally allocating investment assets in an investment portfolio

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INVENTOR-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY
Rebane; George J.	Topanga	CA		

ASSIGNEE-INFORMATION:

NAME	CITY	STATE	ZIP CODE	COUNTRY	TYPE CODE
Saddle Peak Systems	Topanga	CA			02

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PRIMARY-EXAMINER: Cosimano; Edward R.

ASSISTANT-EXAMINER: Hayes; John W.

ATTY-AGENT-FIRM: Ganz; Bradley M.

ABSTRACT:

A computer system and method for optimally allocating investment funds of an investor in a portfolio having a plurality of investments, comprising: determining

a risk tolerance function for the investor specifying the investor's probability preference at each of a plurality of monetary amounts relative to a monetary range relevant to the investor, and allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function.

29 Claims, 12 Drawing figures

Previous Doc Next Doc Go to Doc#

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TITLE: Risk direct asset allocation and risk resolved CAPM for optimally allocating investment assets in an investment portfolio

Abstract Text (1):
A computer system and method for optimally allocating investment funds of an investor in a portfolio having a plurality of investments, comprising: determining a risk tolerance function for the investor specifying the investor's probability preference at each of a plurality of monetary amounts relative to a monetary range relevant to the investor, and allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function.

Brief Summary Text (37):
In accordance with one embodiment of the present invention, a risk tolerance function ("RTF") of the individual investor is determined. The risk tolerance function describes the investor's probability preferences at each of the number of monetary amounts relative to the investor's total assets. More specifically, at a given the monetary amount A, the risk tolerance function for an investor defines the probability PP(A) at which the investor is indifferent between 1) receiving the monetary amount A, or 2) accepting the risk or gamble of receiving an investor defined putative best amount A.sub.H (for `happiness` representing monetary contentment at which net worth the investor is willing to suffer essentially zero risk for further increasing his net assets) with probability PP(A) or losing his monetary assets and ending up at an investor defined putative worst amount A.sub.D (for `despair`) with probability 1-PP(A). The amounts A.sub.D and A.sub.H enclose the investor's total net current assets A.sub.T. Preferably all investment amounts and outcome calculations will be based on A.sub.T and appropriate changes to this value. Some investors may instead consider A.sub.T to be net investable assets or even their net worth. Overall then, the risk tolerance function quantitatively defines the investor's risk aversion or risk seeking behavior with respect to his unique monetary range of specified monetary amounts. Thus, the risk tolerance function is specifically scoped to the investor's actual and unique monetary range which includes his total investment assets so that it realistically quantifies the investor's preferences with respect to potential outcomes effecting the investor's assets, and hence usefully describes (i.e. quantifies probabilistically) the investor's preferences as to the market risk presented by various allocations of investment assets within a portfolio.

Brief Summary Text (38):
The investor's risk tolerance function is derived interactively in a straightforward and systematic manner through a sequence of decisions involving so-called reference gambles. Examples of several risk tolerance functions for three different investors are shown in FIG. 2. In this figure, the normalized PP value varies between 0 and 1 as the monetary outcome ranges from the investor's putative worst amount A.sub.D, to the amount of monetary contentment A.sub.H, such that PP (A.sub.D)=0 and PP(A.sub.H)=1. It is seen that the risk averse behaviors assumed

here are represented by concave downward functions. The straight line joining PP (A.sub.D) and PP(A.sub.H) is the expected monetary value (EMV) line which characterizes the behavior of a risk neutral individual. Consequently the risk seeker's curve lies below the EMV line and is concave upward.

Brief Summary Text (40):
The monetary difference between the PP curve and EMV line at a given PP(A.sub.EMV) value is called the investor's risk premium (RP) and is seen to be the amount the investor is willing to forego or pay in order to avoid the (fair) expected value gamble at PP(A). In the figure we see that all other asset parameters given equal, Investor #1 is more risk averse than Investor #2 since RP1>RP2. Investor #3 appears to be a young person with little total assets who would be risk seeking soon after going into debt.

Brief Summary Text (42):
For any given allocation of investment assets among investments in the portfolio, a probability density function can be determined which describes the rate performance dispersion of the portfolio's predicted market performance. Conventionally, this probability density function is typically expressed with respect to a portfolio defined by fractional weightings of the investment assets, since CAPM is unable to distinguish between the risk preferences of different investors. In accordance with the present invention however, the probability density function of the portfolio's predicted market performance is expressed with respect to the investor's available investment assets, and more particularly, with respect to the investor's risk tolerance function. Thus, this probability density function describes the dispersion of potential monetary gains and losses to the investor given a specific allocation of the investor's investment assets among the portfolio. For a given probability density function, there is a mean or expected value of the probability density function. The probability density function of the portfolio, for example, describes the overall expected performance of the portfolio in monetary amounts.

Brief Summary Text (43):
In accordance with one aspect of the present invention, once the investor's monetary risk tolerance function, and the probability density function of a given investment allocation are determined, it is possible to create a probability density function of the investor's probability preferences with respect to the investor's risk tolerance function. This probability density function expresses the dispersion of risk preferences that the investor would experience as a result of the investment allocation. The expected value of this probability density function of the investor's probability preferences thus describes the overall risk preference of the investor for the specific monetary allocation of investment assets (as opposed to the conventional asset independent risk analysis).

Brief Summary Text (44):
In accordance with the present invention then, investment assets are allocated to the investments of the portfolio by maximizing the expected value of the probability density function of the investor's probability preferences. The probability density function of the investor's probability preferences is determined as a function of the probability density function of the portfolio's predicted market performance with respect to the investment assets allocation policy and the investor's risk tolerance function. The investment allocation that maximizes the expected value of the investor's probability preferences best satisfies these preferences as they are defined by the investor's risk tolerance function.

Brief Summary Text (46):
The probability density function on the probability preference of the investor's risk tolerance function may be determined in a variety of manners in accordance with the present invention. In one embodiment, this probability density function is determined by numerically mapping the probability density function of the portfolio

with respect to the investment assets through the investor's risk tolerance function and onto the probability preference axis. This embodiment is preferable where there is a significant probability of the investor's total assets falling below A.sub.D, the despair amount. Such an outcome is typically predicated by a large rate standard deviation for the portfolio given the investment allocation. The allocation of investment assets amongst the portfolio investments is iteratively adjusted until the expected value of the probability density function on the probability preference axis is maximized. FIG. 3 illustrates an example of the mapping of the probability density function of a given portfolio allocation through an investor's

Brief Summary Text (48):
In an alternate embodiment, the expected value of the probability density function of the investor's probability preferences is determined by direct computation. One method of direct computation is by solution of: ##EQU10## where: g(A) is the investor's risk tolerance function, g(A).epsilon.[0, 1] for A.sub.D .ltoreq.A<A.sub.H, and g(A.sub.D)=0, and g(A.sub.H)=1;

Brief Summary Text (52):
The solution to (13) may be usefully approximated by a truncated Taylor series expansion of g(A), the investor's risk tolerance function, about the expected value of h(A.vertline..function.). One such implementation resolves (13) to: ##EQU11##

Brief Summary Text (54):
An examination of (14) is particularly revealing with respect to asset allocation. The first r.h.s. term is simply a mapping of .mu..sub.A onto the PP axis and is consistent with the fact that all sane RTFs are smoothly and monotonically increasing with A throughout their entire range. The second r.h.s. term is of particular interest since it adjusts the expected value of the mapped cash distribution according to two factors--the curvature of the risk tolerance function and the cash quantified standard deviation of the total portfolio both reflected in the .mu..sub.A region of investor's total assets.

Brief Summary Text (55):
We recall from FIG. 2 that risk aversion is represented by the RTF lying above the EMV line and thereby curving downward with increasing A. This translates to a negative value of the second derivative and means that a term proportional to .sigma..sub.A.sup.2 is subtracted from the direct mapping of .mu..sub.A through the RTF. We will refer to one half the RTF's second derivative evaluated at .mu..sub.A as the portfolio risk compensation coefficient (RCC). Therefore as we assume a portfolio design that increases its expected gain along the CML, we see that .sigma..sub.A also increases. Since the RTF flattens out with increasing A, the RCC becomes less negative, but the increasing .sigma..sub.A effect begins to dominate and the mapped mean, according to (14), reaches a maximum and begins decreasing at the optimal allocation point. The opposite occurs for risk seekers whose RTF falls below the EMV line in the .mu..sub.A vicinity; here the RCC is positive and the risk compensation adds to or augments the directly mapped PP value of .mu..sub.A. This rewards the investor in such a region of his anticipated total assets. Again, in the practical application of the invented algorithm and methodology to realistic short lists of stocks, the `risk seeking portfolio` at a high RCC may be characterized by high variance being traded off against a low mean because the risk seeker fully expects the high variance to work for (not against) him. We presume that current portfolio designers can take comfort from this analysis since a directly evolved form of CAPM risk as defined in Modem Portfolio Theory is very much present in the new RR/CAPM method presented here, albeit expressed in monetary (not rate) terms and mapped into the conflict resolving preference probability space.

Brief Summary Text (56):
In accordance with the present invention, the foregoing analysis and computations

are embodied in a software product for controlling and configuring a computer to receive data descriptive of various investments and their risk characteristics, to interactively determine an investor's risk tolerance function, to allocate investment assets to an investment portfolio, to compute the probability density function of the portfolio's performance with respect to the investor's assets, and to compute and maximize the expected value of the probability density function of the investor's probability preferences. Additionally, the present invention may also be used in a broader context as a monetary risk management tool to determine asset allocations among sectors (e.g. large cap, bonds, growth, value, technology, metals, and the like) and also to select among candidate projects (e.g. acquire XYZ Inc., introduce product line A vs. B, buy new production facility, and the like) in a corporate planning environment.

Brief Summary Text (59):
The upper and lower bounds for each investment are dynamically manipulable, and can be adjusted by the user to change the range of potential allocations to the investment. As the user moves an upper or lower bound to allow an increase or decrease in the allocation, the overall investment allocation policy among the portfolio is automatically recomputed in order to again maximize the expected value of the probability density function of the investor's probability preferences. This user interface thus allows the user to easily and dynamically manipulate the investment allocation and observe the impact of such allocations on the expected return of the portfolio.

Detailed Description Text (36):
Edit limits from existing or provided default values.

Detailed Description Text (50):
The asset allocation program 201 is `stateful system` in that its internal data representation consists of a formal list of data structures and related status parameters having current values. The asset allocation program 201 performs certain functions and processes automatically and in response to user input depending on the current state of the system. The following is a list of `state variables` that are stored by the asset allocation program 201:

Detailed Description Text (55):
Current Allocation Constraints: investor specified limits on the percentages or dollar amounts of the investor's investment assets to be allocated to various ones or groups of investments including a Value at Risk constraint that applies to the overall portfolio.

Detailed Description Text (68):
The investor specifies 605 a scenario of financial factors that will be used to define the optimization requirements. The scenario is input and edited by the user via portfolio editor module 313. The investor inputs values for the following:

Detailed Description Text (69):
Representative epoch for securities (and market). These values define the time period over which the optimization of investment asset allocation is to be computed, and compared with market performance over the same period.

Detailed Description Text (72):
Where individual securities are already known, the investor may input current loads on individual securities, and the investor imposed contraints on each short list candidate, owned stocks, invested, loaned (risk free), and borrowed amounts, Value at Risk. It also includes the buy/sell and portfolio management fees, tax rates, and purchase cost, etc. of owned stocks. Specifically for the stocks it includes the alfas, betas, sigmas, correlation coefficients, valid data epochs (may be different for each stock), for the stocks and the market predictions from FIG. 8.

Detailed Description Text (91):
Referring now to FIG. 7, there is shown an example of an interactive user interface which provides for the primary output of the asset allocation program 201. The portfolio design screen 701 summarizes what investment funds are invested (own 729 and new SL candidates (2-10)), under what constraints they are to be allocated (the bold brackets 707), the actual monetary amounts which the RDAA module 301 or RR/CAPM module 303 allocated to the risky and risk free vehicles (ten securities are shown with their ticker labels 713 indicated along with the risk free amounts 727), and finally the risk compensated portfolio's predicted performance 717. Additional data, such as the computed PP value of the current design and dollar amounts may also be included.

Detailed Description Text (95):
The portfolio design screen 701 may also be assymetrically defined by moving the appropriate crossbar and the display will dynamically update the optimal portfolio solution with the new confidence probability. The lower rounded box 721 always indicates the probability (here 9%) that the portfolio will result in actual reduction of investor's current investment funds. The upper rounded box 717 always indicates the expected portfolio return (here 12%) under the current portfolio design and input financial factors scenario.

Detailed Description Text (96):
From this display 701 the investor may now begin to examine the sensitivity of a given portfolio's risk and return by reconstituting the investment and invested amounts by appropriately changing the size of the bars 709 and constraint brackets 707 on the display 701. In response to an adjustment, the asset allocation program 201 dynamically recomputes the portfolio's performance and continuously updates the display 701. If the investor exactly specifies all invested amounts, then the use of such forced inputs directly calculates the resulting monetary utility PP and does not require numerical optimization. Such a responsive display gives the investor unparalleled insight about how the portfolio responds to different allocation policies. In the final analysis the investor may, of course, opt for a slightly non-optimal portfolio that may satisfy some other non-quantifiable subjective criteria which still produces an acceptable return and risk which he naturally intuits (and has corroborated by the updated PP value display). It should be noted that, the RDAA solution is still optimum within the investor imposed constraints. It should be clear that the less constraints the investor imposes, the higher the PP value (monetary utility) the RDAA module 301 is able to obtain from its optimization. Investor constraints simply reduce the possible maximum PP value.

Detailed Description Text (104):
In this screen display 901, for each of several investor selected portfolios P1, P2, P3, and P4, the performance 903 of that portfolio is plotted against the investor's residual PP value as a function of expected market performance 917 (holding standard deviation constant) at the investment horizon. The vertical axis 903 is scaled in the percent of PP remaining (i.e. 1-PP(A.sub.T) which is a meaningful comparator to the investor since it is indexed from his current asset (A.sub.T) level. The horizontal axis 905 is scaled to expected percent market returns.

Detailed Description Text (105):
The downward shape of the curves P1-P4 indicates that the investor is in the risk averse part of his RTF since the marginal PP gain drops for every additional increment of market return. Generally it is clear that Px is better than Py if and only if Px>=Py over the range of anticipated market performance, however FIG. 9 has no such pair of curves. Rather, FIG. 9 shows the more realistic and difficult situation where some portfolios, eg. P1 and P2, do well with high market performance values but do poorly faster when the market goes down (holding the standard deviation constant) as compared to P3 and P4. Portfolio designs P3 and P4

may be considered more `defensive` and therefore reasonable if there is a significant likelihood of poor market performance. However, the RDAA or RR/CAPM modules already account for any given market performance p.d.f., and thus FIG. 9 shows only the sensitivity to variation in the mean value.

Detailed Description Text (107):
Finally, the investor can view dynamically updated portfolio performance curves Pi by changing the mode of this display to accept as input dragging the expected market return line 917 to a new value (as shown by arrows 919) and adjusting the now symmetrical width of the confidence interval 918 to the confidence level that reflects the new uncertainty in the market's performance. This dynamic, interactive display again provides novel and valuable insight to the sensitivity of the performance comparisons for the competing portfolios.

Detailed Description Text (112):
In the asset allocation program 201, this screen display 1000 enables the investor/analyst to quickly get the `feel` for how RDAA module 301 determines portfolio membership. This feedback is valuable to the investor as he adds new investments to a portfolio that might provide additional diversification benefits. From the figure we notice that the selected investments (Nos. 1, 3, 6 and 8) all have relatively high risk adjusted gains and low cross correlation values. The largest sum is invested in security #8 which itself is unique in the short list because it has an almost uniformly low performance correlation with all the other stocks thereby providing the most diversification value in its inclusion.

Detailed Description Text (115):
Table 1 presents the nominal sequence of reference gambles that the investor is asked to resolve to obtain the points in the A-PP space defined over the total assets line by the investor's A.sub.D, A.sub.T, A,.sub.H values. It is these captured points {X.sub.i, PP(X.sub.i)} which are used to fit the analytical RTF in either single function regression or in cubic spline format. Here the X refers to the cash amounts used in the reference gambles. The RTF module 315 begins by accepting investor inputs of their A.sub.D, A.sub.H, and A.sub.T amounts.

Detailed Description Text (116):
Table 1 is explained as follows. At the start the investor is presented with a choice of 1) taking a certain, perhaps negative, $X.sub.1, thus making his total assets A.sub.T +X.sub.1, or 2) choosing a 50/50 gamble (i.e. toss of fair coin) where winning yields (A.sub.H -A.sub.T) thus bringing his total asset to A.sub.H. Losing the gamble results in a dollar loss of (A.sub.T -A.sub.D) thereby reducing the total assets to A.sub.D. Starting with an arbitrary value, X.sub.1 is increased if the gamble is chosen and decreased if the certain X.sub.1 is chosen. (The process is speeded up if the initial X.sub.1 is such as to keep A.sub.T +X.sub.1, near A.sub.T.) In this manner the investor is quickly driven to the point of indifference or indecision, both indicating that the two alternatives are of equivalent preference. From the computation of the decision graph this becomes the (0.5, A.sub.T +X.sub.1 point on the RTF where PP(A.sub.T +X.sub.1)=0.5= [0.5.times.0+0.5.times.1.0].

Detailed Description Text (117):
The A.sub.T +X.sub.2 0.25) point is determined by asking the investor to choose between 1) taking the certain, perhaps negative, amount X.sub.2, thus making his total assets A.sub.T +X.sub.1 +X.sub.2, or 2) choosing the 50/50 gamble where winning now yields A.sub.T +X.sub.1 -X.sub.2 and losing yields a loss of A.sub.T +X.sub.1 -A.sub.D bringing his total asset to A.sub.D. Again X.sub.2 is raised if the gamble is chosen and vice versa thus bringing the investor to a point of equivalent preference between the presented alternatives. Since the best outcome now had a PP=0.5 (and the worst was, of course, PP(A.sub.D)=0) from the first reference gamble, the current preference probability PP(A.sub.T +X.sub.1 +X.sub.2) is assigned the value 0.25=[0.5.times.0+0.5.times.0.5].

Detailed Description Text (118):
We may now split the 0.5 to 1.0 PP interval to determine the (A.sub.T +X.sub.1 +X.sub.3, 0.75) point by asking the investor to choose between 1) getting the certain amount X.sub.3 added to his now total assets of A.sub.T +X.sub.1, or 2) taking a 50/50 gamble where winning will bring his total assets to A.sub.H and losing will maintain them at A.sub.T +X.sub.1. Again X.sub.3 is raised if the gamble is chosen and vice versa until equivalent preference is reached. The value of PP(A.sub.T +X.sub.1 +X.sub.3) is 0.75=[0.5.times.1.0+0.5.times.0.5].

Detailed Description Text (122):
1. Preference probabilities have a precise definition and can therefore be explained and captured unambiguously. Once A.sub.D and A.sub.H are given, the meaning of any mediating PP is clear. If, for example, an investor's RTF goes through the point PP=0.7 and $1,000,000, this states that the investor is indifferent between receiving $1,000,000 for certain and a gamble that will yield her A.sub.H with probability 0.7 or A.sub.D with probability 0.3. Even though both contingencies are hypothetical, the investor has been able to decide a priori that the value of the certain monetary outcome and the gamble are identical in her monetary spectrum.

Detailed Description Text (128):
The first gamble always determines the PP=0.5 indifference dollar amount that will split the A.sub.D to A.sub.H interval. The subsequent gambles will continue splitting the so generated intervals iteratively while assigning the middle values of PP to the median indifference amounts as obtained from the cases below. It is clear then that the second gamble may be chosen to determine either the 0.25 or 0.75 PP points. These PP intervals may be further split in an arbitrary order. It is almost always the case that obtaining the cash amounts for the intervening PP points 0.5, 0.25, 0.125, 0.375, 0.75, 0.625, 0.875 is sufficient to determine the most complex RTF. The cases illustrated below cover the spectrum of possible reference gambles to obtain the dollar amounts to an arbitrary resolution of the RTF.

Detailed Description Text (198):
We begin by noting that the CML can be quantified to define the expected monetary value of an investor's total assets as

Detailed Description Text (204):
The basic premise behind RR/CAPM and RDAA is that the investor makes monetary choices in uncertain situations according to the investor's specific tolerance for risk as was discussed in .sctn.5.5. Therefore, the salient monetary decisions among alternative portfolios are to be resolved so as to maximize the expected value of PP on the investor's RTF. This is in direct opposition to the conventional view of attempting to represent the risk measure in such terms as the classical \`risk adjusted return\` for an investment computed as its expected rate of return divided by the standard deviation of that rate. The conventional commensurate measure for a portfolio would then be given from (4) and (10) by the ratio R.sub.p (.function.)/.sigma..sub.s (.function.). This further demonstrates how the conventional approach ignores individual attitudes toward monetary risk.

Detailed Description Text (205):
The RR/CAPM approach is based on individual risk tolerance expressed over a bounded and currently relevant monetary spectrum. It takes the probability density function (p.d.f.) of predicted total assets at the end of the investment horizon, as defined by (15) through (18), and maps this onto the individual's PP values as represented by the RTF. This mapping is shown in FIG. 3. Specifically we seek to compute the mean of the mapped distribution on the PP axis given by E(PP.vertline..function.) where .function. is now the appropriate portfolio design fraction vector in the sense discussed above. Let the RTF be represented by the analytical regression g

(A) .epsilon.[0,1] for A.sub.D .ltoreq.A.ltoreq.A.sub.H with all needed derivatives and where g(A.sub.D)=0 and g(A.sub.H)=1. In practice, g(A) need only be locally analytical in the sense described above. Then ##EQU12## where h (A.vertline..function.)is the portfolio's p.d.f. on total assets. Real world (i.e. `sane`) RTFs are appropriately smooth allowing us to closely approximate the function with a truncated Taylor series in the proximity of the mean A=.mu., giving ##EQU13##

Detailed Description Text (220):
With the definition of the first two moments of the predicted assets distribution we compute the expected value of the risk adjusted PP according to (22) using the formulations of .sigma..sub.A and .mu..sub.A given in (29) and (27) respectively. The optimal portfolio then is obtained from the pair ##EQU22## subject to the investor's input of A.sub.1T and the constraint given with (25). N+1 parameters are thus derived from a search over N-space. The amount optimal portfolio design for the simplest case is then given by

Detailed Description Text (222):
Finally, it is clear that this case also covers solutions for portfolios containing only risky securities since we may set R.sub.RF to some large negative value thereby guaranteeing that no funds will be lent at this rate.

Detailed Description Text (227):
These values are used to compute E(PP.vertline..function.,A.sub.1T) in (3 1) and incorporated into the optimum solution (in N+1 space) for the N+2 variables ##EQU24##

Detailed Description Text (258):
5.7.5 Value at Risk and RDAA

Detailed Description Text (259):
We conclude by integrating the concept of Value at Risk (VAR) as a natural inequality constraint to the RDAA (and RR/CAPM) solution. VAR is one of the financial industry's latest attempts to bring together the investor's quantitative aversion to risk and the task of portfolio selection without resorting to utility theory per se. Rather than serve as a substitute for monetary utility, VAR is seen in the sequel as a natural augmentation to the incorporation of monetary utility as presented here. The motivation for this feature is based on the notion or Bernstein's [22] "central idea" of risk as "that variability (which) should be studied in reference to some benchmark or some minimum rate of return that the investor has to exceed."

Detailed Description Text (262):
It is clear that the prescription is readily accessible to the non-technical investor. Eliciting this pair of values will constrain the optimal .function.* to generating predicted portfolio p.d.f.s that limit the probability of loss P.sub.L while still maximizing the risk compensated return of (22). P.sub.L is defined with respect to an amount A'.sub.T which may be the net current assets A.sub.T, or A.sub.T appreciated by placing the total invested amount A'.sub.T at the risk free rate. P.sub.L is then the probability that the investor's net total assets

Detailed Description Text (267):
A last benefit of including the VAR constraint involves expanding the ability of RDAA to tolerate `marginally sane` investor RTFs. This more sophisticated benefit comes into play when the investor--perhaps carelessly--inputs reference gamble points that yield unrealistically low Risk Compensation Coefficient values (i.e. one half times the second partial derivative in (22)) over a part of the amount axis--i.e. the RTF's second derivative approaches zero as the risk premium approaches a linear function of predicted net total assets. In this case the portfolio's volatility, .sigma..sub.A, may be discounted too much by (22) if the

optimum lies in this region of predicted net total assets. Including the VAR constraint, however, causes RDAA to never overlook or discount this fundamental and overriding measure of risk.

Detailed Description Text (273):
Where .mu. is the expected value of investor net assets and .sigma. is its standard deviation. Suppose the maximum amount at risk that can be lost is x.sub.R, then the original p.d.f is truncated at x.sub.R as shown in the figure. The truncated probability mass is redistributed to yield a new p.d.f. given by ##EQU34##

Detailed Description Text (278):
An additional output of interest to the investor is the probability of loss P.sub.L as illustrated in FIG. 12. This same measure of the recommended portfolio is also useful for calculating certain `value at risk` problem formulations (cf. .sctn.5.7.4) and is obtained directly from (63) as ##EQU43##

Detailed Description Text (279):
Finally, since RDAA yields the portfolio's p.d.f. mean and variance in monetary terms, it is possible to compute the total probability P.sub.L of losing money from the recommended investments. The accuracy of this estimated probability is based on the extent to which the portfolio's amount p.d.f. tends to the normal distribution [16]. Within this notion it is possible to conceive of extended RDAA solutions in which the investor adds further constraints to limit this loss probability to a specified level, for example using Value at Risk metrics. In sum, the fimdamental RDAA structure welcomes these kinds of embellishments and extensions.

Detailed Description Text (281):
[1] Keeney, R. L., Raiffa, H., Decisions with Multiple Objectives: Preferences and Value Tradeoffs, John Wiley & Sons, 1976.

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US Reference Group (1):
5774881 19980600 Friend et al. 705/36

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5784696 19980700 Melnikoff 705/36

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5799287 19980800 Dembo 705/36

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5806049 19980900 Petruzzi 705/36

US Reference Group (5):
5812987 19980900 Luskin et al. 705/36

US Reference Group (6):
5812988 19980900 Sandretto 705/36

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5819237 19981000 Garman 705/36

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5852811 19981200 Atkins 705/36

US Reference Group (9):
5884287 19990300 Edesess 705/36

US Reference Group (10):
5911135 19990600 Atkins 705/36

CLAIMS:

1. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising: determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function; and

allocating the investment funds comprises executing the equation: ##EQU44## where f is an allocation policy vector of N risky investments and one risk free investment;

A is a monetary amount expressed over the investor's range of potential net assets;

PP is a monetary preference probability value that quantitatively defines the investor's monetary utility for a monetary amount A;

g() is the investor's monetary risk tolerance function that relates monetary preference probability (PP) to monetary amounts;

.mu..sub.A (f) is the expected value of the investor's net assets amount as a result of implementing allocation policy f, computed from the second probability density function of the portfolio's predicted market performance;

.sigma..sub.A (f) is a standard deviation of the investor's net assets amount as a result of implementing allocation policy f, computed from the second probability density function; and

E() is an approximated expectation of PP from the first probability density function of preference probabilities obtained by mapping the second probability density function of the investor's net assets through the risk tolerance function.

2. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function; and

allocating the investment funds comprises evaluating the equation: ##EQU45## where: g(A) is the investor's risk tolerance function, g(A) .epsilon. [0, 1] for A.sub.D =A<A.sub.H, and g(A.sub.D)=0, and g(A.sub.H)=1;

A.sub.D is an investor defined putative worst monetary amount;

A.sub.H is an investor defined putative best monetary amount; and

h(A.vertline..function.) is the second probability density function with respect to the investor's net asset amount given allocation policy f.

3. The computer implemented method of claim 2, wherein the investor's risk tolerance function g(A) is approximated by a truncated Taylor series about an expected value of the mapped preference probability density function.

7. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising: determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first

probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function;

allocating the investment funds among the investments in the portfolio by mapping the second probability density function for the portfolio through the risk tolerance function to create the first probability density function of the investor's probability preferences;

determining the expected value of the first probability density function; and

repeating the allocating step with a different allocation of the investment funds among the investments in the portfolio until the expected value of the first probability density function is maximized.

8. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an exDected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function; and

wherein the investment funds include borrowed funds at a rate not necessarily equal to the risk free rate.

9. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function; and

wherein the investment funds is further constrained by:

the investor's input of Value at Risk parameters A.sub.VAR and P.sub.VAR that define the maximum value A.sub.VAR the investor is willing to lose with probability P.sub.VAR ; and,

the application of these parameters to guide the solution for the overall portfolio decision vector f.

10. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with

respect to the investment funds and the investor's risk tolerance function; and

allocation of the investment funds to any subset of investments in the portfolio is constrained by:

an upper constraint vector .function..sub.u defining a maximum portion of the investment funds that may be allocated to the subset of investments; and,

a lower constraint vector .function..sub.l defining a minimum portion of the investment funds that may be allocated to the subset of investments.

11. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function; and

allocation of the investment funds to any subset of investments in the portfolio is constrained by:

an upper constraint vector .function..sub.u defining a maximum monetary amount of the investment funds that may be allocated to the subset of investments; and,

a lower constraint vector .function..sub.l defining a minimum monetary amount of the investment funds that may be allocated to the subset of investments.

12. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifving the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability densitv function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function;

receiving at least one market performance prediction for an investment period;

receiving for each market performance prediction an input weighting the market performance prediction;

combining the weighted market performance predictions to define an overall market performance prediction; and

determining the portfolio's predicted performance as a function of the overall market performance prediction.

14. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function; and

displaying for each investment:

a graphical representation of a fractional allocation of the investment funds to the investment;

a graphical representation of a user specified range for the fractional allocation of the investment funds to the investment, the range having an upper and lower bound, each individually movable to redefine the range;

displaying a graphical representation of an expected return for the portfolio given the allocation of the investment funds among the investments; and,

re-determining the expected return and the allocation of the investment funds among the investments in the portfolio in response to an input moving the upper or lower bound of the range of at least one investment so as to require a change in the allocation of the investment funds to the investment.

18. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function; and

determining a plurality of allocations of the investment funds in the portfolio;

determining for each allocation a predicted performance curve of the portfolio given the allocation, the predicted performance defining for each of a plurality of predicted market performance values, a percentage of the investor's residual probability preference resulting from the allocation; and

displaying the predicted performance curves.

19. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with

respect to the investment funds and the investor's risk tolerance function; and

displaying on a single screen:

a first axis of probability preferences scaled between 0 and 1;

a second axis, perpendicular to the first axis, defining a range of monetary amounts including the investment funds;

the investor's risk tolerance function specifying the investor's probability preference at each of a plurality of monetary amounts;

the first probability density function for an allocation of the investment funds, the first probability density function displayed as a distribution on the first axis; and

the second probability density function for the allocation, the second probability density function displayed as a distribution on the second axis.

20. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function; and

providing a plurality of reference gambles to the investor, each reference gamble defining the investor's probability preference with respect to a monetary amount.

25. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function; and

defining a plurality of risk tolerance functions; and

storing each risk tolerance function with data identifying the investor associated with the risk tolerance function;

displaying a plurality of risk tolerance functions;

combined selected ones of the displayed risk tolerance functions to form a mean risk tolerance function; and,

displaying the mean risk tolerance function.

26. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function; and

replacing at least one of the investments from the portfolio with at least one new investment; and

re-allocating the investor's funds among the investments in the portfolio by maximizing the expected value of the first probability density function of the investor's probability preferences determined as a function of the second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function.

27. A computer implemented method of allocating investment funds of an investor in a portfolio comprising a plurality of investments, comprising:

determining a risk tolerance function for the investor specifying the investor's probability preference at each of the plurality of monetary amounts relative to a monetary range relevant to the investor;

allocating the investment funds among the investments to create an investment allocation by maximizing an expected value of a first probability density function of the investor's probability preferences determined as a function of a second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function; and

adding at least one new investment to the portfolio; and

reallocating the investor's funds among the investments in the portfolio by maximizing the expected value of the first probability density function of the investor's probability preferences determined as a function of the second probability density function of the portfolio's predicted market performance with respect to the investment funds and the investor's risk tolerance function.

28. A user interface for a computer system, for evaluating and revising an investment allocation of fractional amounts of investment funds in a portfolio including a plurality of investments, comprising:

a first axis representing a range of fractional allocation values;

a second axis including:

for each investment, a graphical representation of the fractional allocation value of the investment funds allocated to the investment;

for each investment, a graphical representation of a user specified range for the fractional allocation values of the investment funds to the investment, the range having a graphically displayed upper and lower bound, each individually movable by the user to redefine the range; and,

a graphical representation of an expected return for the portfolio given the

investment allocation of the investment funds in the portfolio.

Previous Doc Next Doc Go to Doc#